Prospects for the Conservation of Secondary Forest Biodiversity within Productive Rubber Agroforests

by Eric Penot, CIRAD-CP / ICRAF
and Silvia Werner, Faculty of Environment and Society, Technical University of Berlin

Publication presented at the
CIFOR/USAID International Workshop on
"Management of Secondary Forest in Indonesia"
Bogor, November 1997.

PROSPECTS FOR THE CONSERVATION OF SECONDARY FOREST BIODIVERSITY WITHIN PRODUCTIVE RUBBER AGROFORESTS

by Eric Penot, CIRAD-CP / ICRAF
and Silvia Werner, Faculty of Environment and Society, Technical University of Berlin

Publication presented at the
CIFOR/USAID International Workshop on
"Management of Secondary Forest in Indonesia"
Bogor, November 1997.

Acknowledgments

We would like to thank Dr. Hubert de Foresta (ORSTOM / ICRAF) for the provided advice and information as well as Mss Sandy Williams (Bangor University, UK / ICRAF) for the editing in English. Their help was highly appreciated.

Summary

Since the beginning of the 20th century natural forests in Indonesia have been successively shrinking. Starting with agricultural expansion due to the rubber boom in the first half of the century, followed by logging and plantation development in the second half, primary forests soon will be limited to protected areas. At the end of the same century, jungle rubber is left as the main reservoir of lowland forest biodiversity in the plains of Sumatra and probably West Kalimantan. Because of its nature as a complex agroforestry system, biodiversity and structure of these rubber gardens are similar to old secondary forest. The impact of rubber garden selective cleaning on biodiversity and composition is assessed by comparing them to undisturbed secondary vegetation. Results show that regularly cleaned plots have a distinctly lower biodiversity than not cleaned ones. The presence of rubber by itself has no impact on biodiversity and composition, as it becomes clear if looking at older rubber gardens which are not cleaned anymore. The important conclusion therefore is that management intensity decides upon biodiversity and species composition of complex agroforestry systems.

In times of agricultural modernization, nevertheless, jungle rubber is no longer competitive to other cropping systems like rubber monocultures and oil palm plantations. These monocultures, however, have obvious disadvantages like the need for expensive inputs, susceptibility to diseases and lack of crop diversification. To combine the advantages of both monocultures and traditional rubber gardens, the productivity of jungle rubber should be improved through the integration of innovations, such as clonal rubber and an increase of agricultural inputs and labor. Several types of rubber agroforestry systems (RAS) are currently being experimented in an on-farm trial network by the SRAP project (GAPKINDO/CIRAD/ICRAF). One of them, RAS 1, combines clonal rubber with secondary forest regrowth in the inter-rows. It is expected to be very close to jungle rubber in terms of biodiversity, having a productivity both return-to-labor and yields similar to, or even higher than rubber monocultures. Crop diversification and adapting cleaning intensity to a level where regrowth does not negatively influence yields anymore are effective methods to maximize yield and return-to-labor. Diversification may also imply the selection of economically interesting biodiversity from spontaneous secondary regrowth. RAS integrates biodiversity with improved cropping systems through adaptation to farmers' strategies for land use and resource management.

Traditional smallholders frequently have been criticized for still practicing slash and burn agriculture, and accused of being responsible for fires that destroyed large areas of forest and plantations in 1994 and 1997. It is now recognized that local farmers did not cause the majority of the fires, because properly used, fire in traditional shifting cultivation does not spread. The farmers actually are interested in decreasing shifting cultivation (for the purpose of upland rice production) and are putting emphasis on more intensified and more productive systems based on tree-crops that require less land, such as clonal rubber or oil palm or, even, new alternatives such as RAS which produce a far more interesting return-to-labour and reduce risks. Improved RAS increase farm income while requiring less land per household and support the development from shifting agriculture to a permanent tree crop based agriculture. The role of rubber agroforestry as an interesting alternative to other systems like oil palm or pulp trees are also discussed in this paper, as well as the potential for RAS systems to rehabilitate *Imperata* grassland.

1 Complex AgroForestry (CAF) Systems : Rubber agroforests for incorporating more biodiversity into productive rubber cropping patterns in Indonesia

Introduction

In the course of the 20th century large parts of the tropical lowland forests in the wide plains of Sumatra and Kalimantan have been put into commercial use. Local agriculture up to the end of the 19th century was limited mainly to subsistence shifting cultivation. Only in the coastal areas and parts of North Sumatra colonial powers had established cash crop production. This situation changed in the early 20th century through the introduction of the rubber tree to Indonesia. The consecutive rapid spread of rubber cultivation by local smallholders caused more than 2.5 million ha of the two humid tropical islands to become covered by rubber based complex agroforestry systems[1], providing income for more than 1 million farmers (DGE, 1996). We may wonder why rubber was adopted so quickly by farmers at such a large scale. One reason is certainly that "rubber filled a niche that was previously filled by the native rubber forests" (Dove, 1994). It provided a cropping opportunity for poor soils: at least up to the 80's rubber was almost the only possible cash crop for areas of low fertility like the central plains of Sumatra and Kalimantan. Rubber agroforests have also permitted formerly migrating Dayak groups to establish permanent villages and in Sumatra they provided a livelihood for spontaneous Javanese migrants. The development from shifting cultivation and forest rubber exploitation (from 'Gutta percha' / *Pallaquium spp* trees) to the planting *Hevea brasiliensis* for rubber production not simply replaced one tree with another but also exchanged one mode of production for another (Dove 1994). It illustrates the shift from collection to production, from "original forest", to "cultivated forest".

Forest conversion through this rubber boom was followed by the onset of commercial logging in the 1960s and 1970s which is still on-going. Parts of the forest being logged was intentionally clear-cut for land conversion in the frame of government sponsored transmigration schemes, moving landless farmers from crowded Java to the less populated Sumatra, Kalimantan, and other outer islands. Many logging concessions, however, are located within forest classified as production forest, where no transformation to other land uses was intended. Excessive timber exploitation, however, left these forests frequently in a very poor state. A lack of replanting and their uselessness as production forests consecutively was used as a justification for a conversion of these logged-over forests to industrial timber plantations. In the 1980s and 90s, this trend was accelerated by a strong demand on oil palm and pulp, triggering large scale pulp plantation and oil palm estate development schemes. While the former are located mainly in former concession areas, the second are increasingly established on village lands. This is especially true in the last few years, where oil palm development schemes moved from merely targeting transmigration areas to local smallholders, partly shifting cultivators and most of them rubber planters (see also Dove 1985 and 1986 for a description of processes and related problems in West Kalimantan).

The last phase of the process of forest conversion and agricultural intensification has important consequences for local biodiversity. Secondary forests, the result of shifting cultivation, have been an important refugium for parts of primary forest biodiversity in rural areas. With increasing pressure put on remaining resources by a variety of stakeholders, local people try to put claim on

[1] Agroforests and complex home gardens are the 2 sub-groups making up the Complex AgroForestry systems (CAF) group. The word complex refers herr to the sructure and the biodiversity of the system , not to the establishment of management processes which are indeed quite simple (H. de Foresta & G. Michon, 1997)

Presentation of RAS trials **RAS 1 rubber + secondary forest regrowth**

The first trial (RAS 1) is similar to the current jungle rubber system, in which unselected rubber seedlings are replaced by adapted clones. The main objectives are to determine if clonal rubber germplasm thrive in a jungle rubber environment , to double yields and to assess the required minimum management level . A secondary objective is to assess the level of biodiversity conservation in the jungle rubber system. The rubber clones must be able to compete with the natural secondary forest growth. Various weeding protocols will be tested. Two planting density has been chosen : 550 and 750 rubber trees/ha. This will identify the minimum amount of management needed for the system, a key factor for farmers whose strategies depends on labour and cash availability. RAS 1 requires a certain level of existing biodiversity in the surrounding area (old jungle rubber, Tembawang or other types of timber/fruit agroforestry systems, home gardens, secondary or primary forest...) for establishment. In effect, RAS 1 is aimed for planting in pioneer or very remote areas or replanting in old jungle rubber or secondary forest areas. RAS 1 is not suitable in Imperata grasslands (Penot, 1995, de Foresta, 1994).

RAS 2 : rubber + associated trees + annual intercrops

The second trial, RAS 2, is a complex agroforestry system in which rubber and perennial timber and fruit trees are established after slashing and burning, at a density of 550 rubber treesand a range of 90/250 other perennial trees per hectare (with various planting densities and selected species according to a typology). It is very intensive, with annual crops being intercropped during the first 3-4 years, with emphasis on improved upland varieties of rice, with various levels of fertilization. Intercrops are annual (predominantly upland rice or a rotation of rice/leguminous crops such as groundnut) or perennial (cinnamon), during the first years of establishment. Previous experimentation has shown the positive effect of annual intercropping on rubber growth (G Wibawa, 1995, 1996, STD3/EEC reports). The range of trees that can be grown in association with rubber in agroforestry associations and the market potential of their products are being examined–tekam, meranti, myatoh, and sunghai trees for timber, durian, rambutan, duku, langsat, cempedak, petai and jengkol for fruit, tengkawang and kemiri for nuts.

RAS 3
Rubber+associated trees+covercrops+pulptrees
For Imperata grasslands rehabilitation

The third system, RAS 3, is also a complex agroforestry system with rubber and other trees planted at the same density as that as RAS 2 but with no intercrops except the first year, followed by a combination of covercrops, MPT's[5] and Fast Growing Pulp Trees (FGT). It is established on degraded lands covered by *Imperata cylindrica* (alang-alang grass) (E Penot, 1995). The grass precludes the growth of annual crops so selected cover crops *(Mucuna, Flemingia c., Crotalaria, Setaria, Chromolaena o.....)* or MPT's (*Calliandra*, Wingbean, *Gliricidia s.*) and FGT (*Gmelina a., Paraserianthes f., Acacia m,)* are established. The objective here is to eliminate the weeding requirement by providing a favourable environment for rubber and the associated trees to grow, supplanting and then preventing *Imperata* growth. All these trials are documented in SRAP methodology project documents (SRAP 1995, 1996).

---

[5]MPT's = Multi Purpose Trees

lands through an accelerated planting of tree crops into their upland field which otherwise would be left fallow (Dove 1993a, Werner 1997). Resulting rubber agroforests, commonly called jungle rubber[2], replace now the role of secondary forests for biodiversity conservation in rural areas. And with primary forests vanishing, they remain the only refugium for forest species in many areas. The replacement of rubber gardens with oil palm estates therefore has not only implications for the local economy, but also for biodiversity. Several types of improved Rubber Agroforestry Systems[3] (RAS) are currently being experimented at large scale in three provinces of Indonesia and managed by GAPKINDO[4], CIRAD[5] and ICRAF[6] in an on-farm trial network. RAS systems are defined in box 1. The On-farm-Trials network established by SRAP is summarized in the following table :

Table 1 FARMERS AND AGRICULTURAL SCHOOLS INVOLVED IN RAS ON FARM EXPERIMENTATION

Province	*Village*	*Trial type*	*Farmer*	*Agricultural school*
West Kalimantan	5	15	63	1
Jambi	3	7	26	1
West Sumatra	1	3	8	-
Total	**9**	**25**	**95**	**2**

The SRAP[7] project, however, could prove, that improved Complex AgroForests[8] (CAF), in particular RAS, are not only cheaper concerning their development costs, but also can compete with oil palm plantations in respect of their output (Penot 1997). Although being impressed by success-stories about oil palm plantations, smallholders generally prefer rubber gardens, because of being already used to the plant and related production practices (Werner, unpublished data).

Indonesian farmers have developed a wide range of agroforests in Sumatra and Kalimantan, based on variable products such as rubber, *damar* resin, illipe-nut, timber, benzoin, durian and other fruits (Michon, 1997). Among these agroforests, rubber agroforest are the most widely found system (see figure 1 and 2). This is clearly a "production system" as opposed to an "extractive system" of primary or secondary forest resources, however extractivism can also be a side-activity in complex agroforests, but not the main source of income. Each Complex Agroforest has generally a main driving economic force : Rubber, damar, timber, durian, cinnamon, salak, benzoin....

These rubber agroforests maintain a certain level of biodiversity which is quite high compared to monoculture and relatively close to that of secondary forests as it will be developed in this paper.

2 Jungle rubber is the translation of *hutan karet*, which, however, sounds backward to some policy makers. We will therefore use the word rubber agroforest , equivalent to "rubber gardens" or *kebun karet*.

3 RAS are improved rubber based agroforestry systems as defined by SRAP, using rubber clonal planting material with various levels of maintenance, fertilization, and combination with annual and perennial trees.

4 GAPKINDO is the Natural Rubber Association of Indonesia.

5 CIRAD is the Centre de Coopération Internationale de Recherche en Agronomie pour le développment, France.

6 ICRAF = International Center for Research in Agroforestry.

7 SRAP = Smallholder Rubber Agroforestry Projet, a joint research programme of CIRAD, GAPKINDO and ICRAF/Southeast Asia regional programme.

8 Agroforests and complex home gardens are the two sub-groups making up the Complex AgroForestry systems (CAF) group. The word complex refers here to the structure and the biodiversity of the system, not to the establishment of management processes which are indeed quite simple (De Foresta and Michon 1997)

The low productivity of rubber agroforests requires an improvement through the adoption of some innovations such as improved planting material. Several improved Rubber Agroforestry Systems (RAS) are currently being under experimentation and can be already considered as reliable and interesting alternatives to current jungle rubber and rubber monoculture systems. The purpose of this paper is to show that in light of the continuous deforestation and in addition to the conservation areas, there is a scope for RAS with high productivity, to conserve a certain level of secondary forest biodiversity within production systems.

Defining rubber agroforests

First of all, rubber agroforests have to be clearly defined to avoid a mixing up with other terms like improved fallows, enriched secondary forests or community forests managed by local tenants. Differing from the land use systems mentioned before, rubber agroforests are tree-crop plantations and can be fully considered as a cropping system (other examples would be upland rice, paddy rice, oil palm or homegardens). This is due to the fact that the system does harbor trees that grow from natural regeneration but initially had been established through the planting of trees. CAF are not "enriched secondary forest" but planted rubber plots with a lot of tree weeds (De Foresta, 1992). These rubber gardens can be either termed a "cultivated forest" or "a complex agroforest", implying by definition that part of the germplasm existing in the system has been planted by farmers for production (Penot, 1997). We adopt in this case, clearly a farming system perspective where the farmers develops a strategy in allocating land, capital and labour to these different cropping patterns.. The important word is "cultivated ".

The important characteristic of CAF like RAS is that they are managed in a planned way. Agronomists are inclined only to consider simple monocultures, either based on trees or annual foodcrops, or agroforestry with a limited level of combination between trees and crops, with an emphasis on crops, as cropping systems. In the *common sense* of agriculture, forest-like structures, even if cultivated, belong to the world of forestry. Therefore the question arises if complex agroforests, featuring “tree-tree combinations” can be classified as forestry cropping systems or an agricultural cropping systems?

This question still remains unanswered for rubber agroforestry systems, because rubber is considered as an agricultural product not a forestry product (except for rubber wood[9] use). The problem stems from the fact that complex agroforestry systems, and in particular those based on an agricultural commodities (e.g. rubber or benzoin) are exactly in between these two worlds: forestry and agriculture.

Development of rubber agroforests

The history of rubber agroforests and the pros and cons of this cropping system have already been well described in several publications (Barlow, 1982, Gouyon *et al*., 1993, Gouyon, 1995, Levang, 1993, De Foresta, 1990 and 1992, Penot 1996). The history of innovations, and their integration into rubber agroforest and related adoption processes have been illustrated by Penot (1997). These CAF, planted with unselected seedlings, generate up to 80 % of the total farm income of rubber smallholders (Gouyon, 1995, Kelfoun, 1997). The main advantages of rubber agroforests are the following: no cost of establishment, limited labor requirements during the immature period of rubber (ranging from 8-10 years in Sumatra to 12-15 years in West-Kalimantan), income

[9] Rubber wood can be used for making furniture, particle board, plywood, pulp and firewood.

diversification through a high level of biodiversity (fruits, nuts, timber, rattan, other NTFPs / Non Timber Forest Products) and no economic risk due to plantation failure as planting material is free. The biodiversity contained in such systems will be presented in chapter 3.

The main constraint of these traditional rubber agroforestry systems mentioned above is their low productivity resulting from the use of unselected rubber seedlings (average production 500 kg/ha/year of dry rubber, compared to 1500 - 1800 kg/ha/year for systems using clonal rubber). It is therefore crucial to select those cropping patterns generating the most income and to assess the components that can increase productivity. Other important considerations for RAS development relate to conserving the very nature and advantages of agroforestry practices that optimize labor, minimize labor requirements during the immature period as well as provide income diversification (Penot, 1996).

This are the objectives of the SRAP project concerned with Rubber Agroforestry Systems. Several systems are currently in experimentation at farm level in three Indonesian provinces. RAS experimentation has been well documented by Penot (1994, 1996, 1997), and in particular through the papers presented at the SRAP workshop (Bogor, September 1997). The main idea of SRAP is to provide sustainable rubber based agroforestry systems with a high level of productivity of both rubber and other products (fruits, timber, intercrops, etc.) while maintaining a certain level of secondary forest biodiversity. In an environment of decreasing land availability for local agricultural expansion, improved RAS, as productive cropping patterns harboring biodiversity, also reduce the amount of land required per family. This is due to the characteristic of RAS supplying a variety of marketable as well as subsistence crops within a single system. RAS therefore provide for income diversification and household needs which otherwise would have to be sought elsewhere. This is an important contribution for local economic sustainability.

Rubber agroforest as a refugium for forest biodiversity

The maintenance of biodiversity is not a priority objective for farmers to the extent it is for ecologists. It is a by-product resulting from farmers balancing the need to clean gardens for yield optimization with labor efficiency maximization, i.e. the point where further cleaning does not compensate for yield increase anymore. Part of the resulting *vegetal biodiversity* is economically valuable, another part might be otherwise important for the daily needs of local populations (such as medicinal plants), but is not taken into account for economic calculations. It is clear that biodiversity not interesting for farmers as a concept. It means different things for them: a source of additional income through fruits, timber and NTFPs from other trees than rubber, and also a source of seeds for replanting trees in degraded areas, in particular Imperata grasslands[10]. For Dayak farmers in the Sanggau/Sintang areas, land use at the village/community level is clearly balanced between production oriented cropping systems (including rubber agroforests and *tembawang*), managed forests and forests protected by customary law to guarantee a permanent supply of forest products. Conservation of biodiversity in CAF as an integral part of the land use system (Werner, 1993) seems to be the best way of local resources management.

This raises the question of the value of biodiversity and how to maintain it: though integration, segregation or through both (Noordwijk *et al.*, 1995). Looking closely at the pioneer zones, at any intensification process or deforestation trend in Africa and Southeast Asia, it appears that the only way to maintain a certain amount of the forest area as unspoiled as possible, is to allocate part of the

[10] In particular like the Dayaks in a transmigration sheme in Pariban Baru, Sintang area (survey by Courbet 1997)

1 In lowland areas ($\leq$ 200 m a. p. l.) in Sumatera, "a rubber jungle" can now be considered as the largest and richest reserve of forest plant and animal genetic resources.

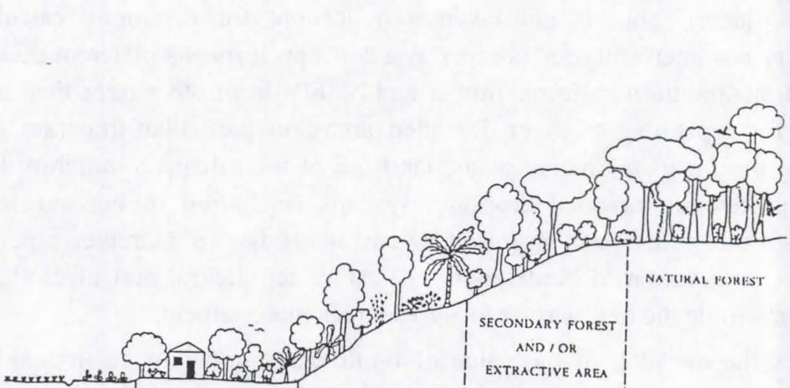


Fig. 2 The land-use spectrum in Benawai Agung, West Kalimantan, Indonesia. Derived from Salafsky et al. [1993a] and Michon et al. [1986].

land to forest conservation and enforce laws on forest protection. Ivory Coast is an example where severe deforestation (15 million ha in 1960 were reduced to 0.5 millions ha in 1995) is a result of forest conversion to coffee and cocoa plantations and where the only remaining primary forest is the Tai National Park in the South-West. This shows that "segregation" is necessary, but not sufficient. So "integration" should be considered, at the condition that productivity is not affected. Rubber is one tree crop that allows such an integration. The main hypothesis therefore is: "*Production with unselected seedlings in jungle rubber and monocultures results in similar yields, i.e. around 500 kg/ha/year, showing no negative impacts of competition from associated trees to rubber. Therefore it is probably the same for clonal planting material*".

As long as the following conditions are prevalent

* land is available
* abundance of a permanent source of immigrants (Java in Indonesia, the Red River and the Mekong valleys in Vietnam)
* existence of easy and low risk cropping patterns allowing income generation through agriculture (e.g. rubber in Indonesia, cocoa in RCI)
* markets able to absorb any increase in production

deforestation will occur until primary forest has vanished. Simultaneously with infrastructure development, forests, primary and secondary, are disappearing rapidly. This are typical conditions of any "crop boom" (Ruf 1990, Penot 1997, Werner 1997), whose characteristics usually exhibit little scope for natural forest to stay protected as long as the market is driving the boom.

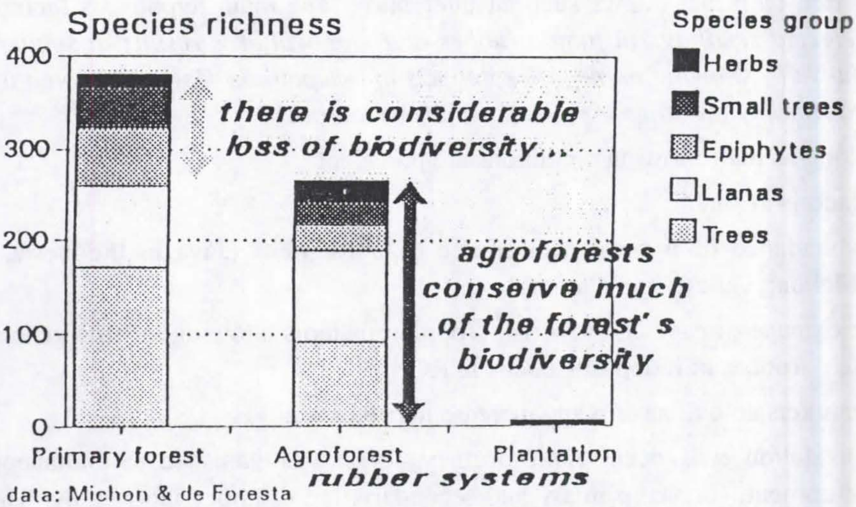
With primary forest shrinking and efficient and productive monocultures such as rubber and oil palm increasingly spreading the necessity for an integration of biodiversity into the agricultural production system has to be considered to provide refugium for secondary and partly primary forest species. There may be little scope to integrate biodiversity into oil palm plantations without seriously jeopardizing productivity. This is possible, however, within rubber gardens. Without real law enforcement on national parks and/or community based land allocation and management, it seems to be necessary to also "integrate" biodiversity into some cropping patterns, at least those that enable a sufficient income for farmers without disturbing the production potential. Few crops can really fulfill that last condition and rubber is one of them.

The extension of rubber agroforests has been one driving force of the deforestation process during the 20th century in Sumatra and Kalimantan. At the end of the 20th century, however, they are the major reservoir of biodiversity in rubber growing areas where natural forest have almost disappeared (De Foresta 1995, Laumonier 1992). One hypothesis concerning RAS is that the expected biodiversity of RAS, and in particular of the RAS 1 system, will be similar to that of current jungle rubber, and therefore very similar to that of a secondary forest (see figure 3 & 4 and chapter 3 for a comparison of rubber agroforest and secondary forest biodiversity).

RAS 1 is a system very similar to that of current jungle rubber, using rubber clones and a reduced amount of labor for weeding and fertilization during the first two years to boost growth and enable clones to compete with the secondary vegetation in the inter-rows. RAS 1 is similar to what Dutch planters in the 1920 and 1930 called "the jungle weeding", where weeding in the inter-rows was replaced by secondary forest regrowth (Dijkman, 1951).

If allowing secondary forest regeneration in between planted trees (e.g. rubber, *damar*, illipe nut) farmers usually select the economically interesting part of the natural biodiversity, like fruit and timber trees, rattan and other NTFPs during cleaning efforts. These tree based cropping pa

Figure 3 Two perspectives on higher plant biodiversity in agroforests



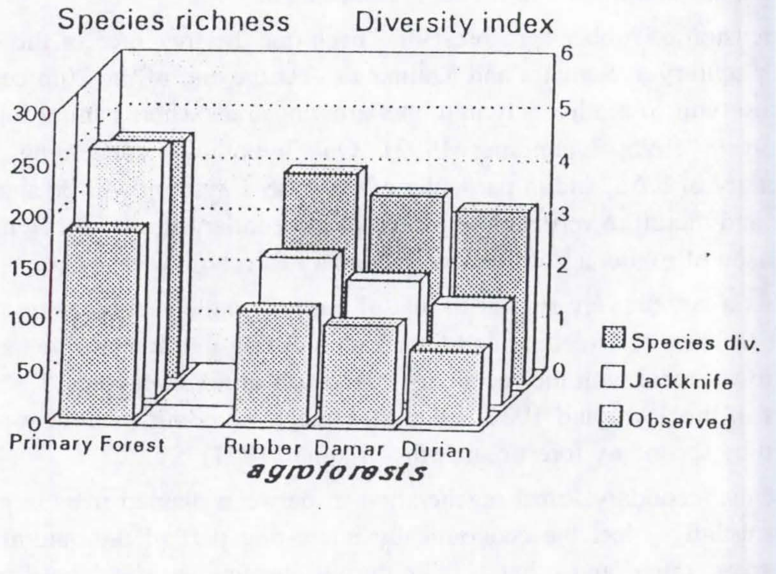


Figure 4 Agroforests and bird conservation in Sumatra (Thiollay 1995)

land to forest conservation and enforce laws on forest protection. Ivory Coast is an example where severe deforestation (15 million ha in 1960 were reduced to 0.5 millions ha in 1995) is a result of forest conversion to coffee and cocoa plantations and where the only remaining primary forest is the Tai National Park in the South-West. This shows that "segregation" is necessary, but not sufficient. So "integration" should be considered, at the condition that productivity is not affected. Rubber is one tree crop that allows such an integration. The main hypothesis therefore is: "*Production with unselected seedlings in jungle rubber and monocultures results in similar yields, i.e. around 500 kg/ha/year, showing no negative impacts of competition from associated trees to rubber. Therefore it is probably the same for clonal planting material*".

As long as the following conditions are prevalent

* land is available
* abundance of a permanent source of immigrants (Java in Indonesia, the Red River and the Mekong valleys in Vietnam)
* existence of easy and low risk cropping patterns allowing income generation through agriculture (e.g. rubber in Indonesia, cocoa in RCI)
* markets able to absorb any increase in production

deforestation will occur until primary forest has vanished. Simultaneously with infrastructure development, forests, primary and secondary, are disappearing rapidly. This are typical conditions of any "crop boom" (Ruf 1990, Penot 1997, Werner 1997), whose characteristics usually exhibit little scope for natural forest to stay protected as long as the market is driving the boom.

With primary forest shrinking and efficient and productive monocultures such as rubber and oil palm increasingly spreading the necessity for an integration of biodiversity into the agricultural production system has to be considered to provide refugium for secondary and partly primary forest species. There may be little scope to integrate biodiversity into oil palm plantations without seriously jeopardizing productivity. This is possible, however, within rubber gardens. Without real law enforcement on national parks and/or community based land allocation and management, it seems to be necessary to also "integrate" biodiversity into some cropping patterns, at least those that enable a sufficient income for farmers without disturbing the production potential. Few crops can really fulfill that last condition and rubber is one of them.

The extension of rubber agroforests has been one driving force of the deforestation process during the 20th century in Sumatra and Kalimantan. At the end of the 20th century, however, they are the major reservoir of biodiversity in rubber growing areas where natural forest have almost disappeared (De Foresta 1995, Laumonier 1992). One hypothesis concerning RAS is that the expected biodiversity of RAS, and in particular of the RAS 1 system, will be similar to that of current jungle rubber, and therefore very similar to that of a secondary forest (see figure 3 & 4 and chapter 3 for a comparison of rubber agroforest and secondary forest biodiversity).

RAS 1 is a system very similar to that of current jungle rubber, using rubber clones and a reduced amount of labor for weeding and fertilization during the first two years to boost growth and enable clones to compete with the secondary vegetation in the inter-rows. RAS 1 is similar to what Dutch planters in the 1920 and 1930 called "the jungle weeding", where weeding in the inter-rows was replaced by secondary forest regrowth (Dijkman, 1951).

If allowing secondary forest regeneration in between planted trees (e.g. rubber, *damar*, illipe nut) farmers usually select the economically interesting part of the natural biodiversity, like fruit and timber trees, rattan and other NTFPs during cleaning efforts. These tree based cropping patterns differ with the level of planting and selection farmers decide to apply and can be classified either as a cultivated forest or as a complex agroforestry system, depending on the level of extraction and production present enable (see typology established by Michon, 1997, personal communication). However, secondary forests[11] and even over-logged forests are richer in terms of biodiversity than any type of agroforest ever can be. Therefore they can be no substitute for natural forest conservation.

Je suis la

2 The role of CAF in farming systems

In West-Kalimantan Dayaks farmers traditionally manage their natural resources according to customary law. Land is allocated for paddy rice, upland rice and related fallow lands[12], rubber agroforests, rubber monoculture plots, home gardens and *tembawangs*. *Tembawangs* are complex agroforestry system based on timber and fruits, managed individually or communally (De Jong, 1992-1995, Momberg 1993, Werner 1993). In the latter case, timber extraction can be done not for cash generation but only for personal use, which is generally house construction. Dayak communities manage their land with a balance between conservation and production, with *tembawangs* standing in between - once established, they are rarely cut down again. Land used for further tree crop gardens usually is the land used for upland farming. These areas consecutively shrink through the extension of more productive systems such as rubber or oil palm monocultures. Nevertheless, some forests are protected within village land through customary law, allowing for various level of use, from total conservation to a level similar to that of *tembawangs* (case study of Sanjan village in the Sanggau area, Momberg 1993).

Although the government partly regulates land use up to the village level, it becomes clear that local communities are perfectly able to implement a correct balance between conservation and production by themselves, as long as their general conditions allow for the implementation of cropping systems that raise a sufficient income. Land tenure insecurity and other external pressure factors leading to marginalisation usually have a negative impact on the ecological sustainability of land management practices. Adoption of improved CAF therefore is linked, on one the side, with farmers resources and, on the other side, land use policy.

CAF and the problem of official recognition

Systems using clonal rubber are one potential alternative to oil palm or rubber monoculture on the condition that these CAF can be fully recognized by the governments as well as by research and development agencies as *cropping systems*. CAF, and in particular RAS using high yielding rubber planting material, are definitely no "backward" systems as they are generally considered by agricultural officials. The reason for the low productivity of traditional RAS partly is due to the government's emphasis on the development of monocultures during the last decades, using costly

---

[11] At that point , it seems relevant to precise the definition of secondary forest. Secondary forest is composed of untouched natural vegetation that grows after a complete slash and burn and cultivation ("belukar" in Indonesian). In a rather severe logging (if 15 to 25 timber trees are removed per hectare for instance), the remaining forest is seriously degraded and can be considered as a depleted primary forest. Secondary forest is not fundamentally modified by man, at least after slash and burn and generally 1 or 2 years or upland crops, but is let to grow 'naturally". The very difference is in the fact that a secondary forest is not planted.

[12] For one field of upland rice, 5 - 10 fields of secondary vegetation have to be present, representing the average duration of the fallow period.

Table 2 "Jungle rubber", structural and floristic data.
Desa Sukaraja, study plot: 35 years old, 1000 m2.

a/ DBH 10cm and above: trees in the canopy

Species	Local name	Herbarium specimen H.F. n°	Frequency (1000 m2)	N° on the drawing first half (500 m2)
Hevea brasiliensis	Karet		49	h
Nephelium lappaceum	Rambutan	2350	9	31; 53; 61'
Milletia atropurpurea	Meribungan	2349	3	2; 3
Schima wallichii	Serou	2024	3	29; 86
cf. Rosaceae	Genetri	2347	3	23; 26; 47
?	Malang siro	2341	2	second half
Artocarpus integer	Cempedak	2342	1	64
Lithocarpus cf. elegans	Lampening	2344	1	20
Dillenia sp.	Simpuh	2311	1	second half
Euphorbiaceae	Pelangas	2348	1	second half
Lauraceae sp.	Medang seluang	2343	1	79
cf. Ulmaceae	Samak jalak	2340	1	second half

b/ DBH less than 10cm: tree species abundant in the undergrowth.

Species	Local name	Herbarium specimen H.F. n°
Helicia cf. robusta	Seranto tua	2325
Grewia paniculata	Talok	2346
Rhodamnia cinerea	Merpoyan	2345
Psychotria malayana	?	2334
Ixora cf. congesta	?	2335
Bellucia sp.	Jambu amerika	2329

5

technology packages and requiring thorough extension. Because of the high amount of resources needed for this approach, only small parts of the rubber smallholders could be reached yet. The success rate of the technology packages also were quite low due to the fact that the intensity of extension and timely providence of inputs required by the program set-up could not always be implemented in the field (Barlow and Tomich 1991). High prices of improved planting material as well as heavy expenditures for the required inputs while credit facilities are still lacking hamper the spread of improved varieties outside of government programs (Barlow and Jayasurija 1986, Gouyon *et al.* 1993).

Another reason for the lack of support given to traditional RAS relates to the government tendency mentioned by Dove (1993b) of trying to control the production of booming commodities through the establishement of government-supervised units or the support of commercial plantations. Resultingly, until the early 1980s, government support for tree crop development was mainly focused on the estate sector. Although smallholders dominated rubber production, for example, until that time only 8% of the Indonesian smallholders participated in government programs to improve productivity (Booth 1988).

A priority of SRAP therefore is to advocate cost-effective, less complicated RAS employing improved varieties, but integrating traditional management practices. Government priorities on monocultures and nation-wide employed technological packages partly stem from the times of the green revolution, where these approaches to food crop agriculture resulted in high yield increases. They seem, however, not to be so suitable for smallholder tree crops, where the downside of the green revolution like the new systems' susceptibility to diseases and sensitivity to unprofessional management becomes very prominent. In 1995 therefore a change in official programs might indicate a recognition process, with DISBUN[13] emphasizing on annual intercropping in rubber monocultures; a practice that was forbidden earlier, like e.g. within the TCSDP[14] program. The integration of foodcrops as intercrops during the rubber immature period is already a traditional practice, but which can be comfortably matched even with improved rubber varieties. Although not at the plot level, but at the farm level, even oil palms and rubber gardens can be integrated. There are no significant labor constraints preventing this and forcing the farmer to chose either of both, as it is still common practice up to now.

Access of farmers to improved cropping technologies as well as a related recognition of land and tree tenure up to now are the main critical issues related to RAS and other CAF. The constraints, however, are rather of institutional or political than of practical background. At the farm level, capital is not really a constraint for improved, but less expensive systems, such as the RAS tried within the SRAP project (Penot 1996, Kelfoun 1997). Land is only a real constraint in transmigration areas. Two to three hectares of improved CAF would provide a sufficient household income, as productivity of CAF is very similar to that of monocultures. In fact, we also should take into account the "long-term sustainability of farms" and calculate the amount of additional land which will be necessary for the second generation. On that basis, the real area required per farm might be six to eight hectares per family, i.e. including the necessary land reserve for the second generation. AND THEN, THE THIRD GENERATION AND SO ON? The increase of income through a better productivity and the improvement of return to labor for CAF will limit land requirements per family, allowing a higher population density and a better land allocation at the community level.

---

[13] DISBUN = Dinas Perkebunan = Tree Crop Service

[14] TCSDP = Tree Crop Smallholder Development Project, partly based on rubber, implemented in the early 1990s.

3 COMPARISON OF BIODIVERSITY BETWEEN FOREST AND AGROFOREST IN INDONESIA

Source	Location	Sampling size	Primary forest		Secondary forest 10 years old			
					2 years cropping after S&B		Several cropping after S&B	
			Nb of trees	N of species	Nb of trees	N of species	Nb of trees	N of species
D Lawrence	West Kalimantan Ketapang/Gunung palung	3000 m²	357	144	317	24	313	18
	Kembera	1 ha	584		523			
L Sundawati	West Kalimantan PFMA/Sanggau							
H de Foresta		100 m long transect line	258	171				

Source	Location	Sampling size	Rubber agroforest				Tembawang	
			Nb of trees	N of species	Nb of rubber trees	Nb of other trees	Nb of trees	N of species
D Lawrence	West Kalimantan Ketapang/Gunung palung	3000 m²						
	Kembera	1 ha	337		217	120	406	
L Sundawati	West Kalimantan PFMA/Sanggau			36				90
H de Foresta		100 m long transect line	247	92				
H de Foresta	South Sumatra Sukaraja 35 years old	1 ha	516		490	26		
Pramoth	Jambi Muara buat	1 ha	1574		660	914		

Note : all trees with dbh>10 cm excpt Pramoth, 1 to 10 cm.

Source : H. de Foresta, 1991 ; D. Lawrence, 1996, 1997 ; L Sundawati, 1993 ; Pramoth, 1992 ;

RAS 1 is the system being closest to jungle rubber farming practices but requiring more labor, in particular for minimum weeding, and some capital for clonal rubber plants and fertilization. Labor requirements have been minimized in particular during the immature period, and capital required for establishment is less than that of monocultures to make it more affordable to farmers. Income is similar to that of monoculture, so is the return to labor (Penot 1996). Other RAS systems are also very interesting in terms of productivity and composition as their different levels of intensification may fit various farmers strategies. Their level of biodiversity is limited to the planted species, at least at the beginning, but a relatively extensive management later favors a process of species enrichment.

3 Jungle rubber as a reservoir for biodiversity

Rubber agroforest have been well described in Sumatra and Kalimantan (by Colfer *et al.*, 1988, De Foresta 1990, Sundawati 1993, Lawrence 1996, Salafsky 1994, Momberg 1993, Werner 1993, Pramoth Kheowvongsri 1990). The comparison of biodiversity for collembole, birds (Thiollay, 1995) and vegetation shows that rubber agroforests are very close to secondary forest. A preliminary characterization has been done by H de Foresta in South Sumatra (table 2 & figure 5). D Lawrence found rubber agroforest less rich than that of Sumatra, at least in the Gunung palung area in West Kalimantan, (see in annex, table 2) but it is partly due to the assessment method. If all trees above West Kalimantan (Ketapang area) DBH >1cm are taken into account, then the number of species and number of trees per ha are potentially similar to the South Sumatran situation. The methodology of biodiversity assessment is very important for comparison. Table 3 shows some comparison between forest and agroforests for various authors, however it seems quite difficult to compare results.

Jungle rubber or traditional smallholder rubber gardens in Indonesia in the view of conservative agriculturists usually bear the stigma of lack of care and management skills. While it is true, that yields from jungle rubber gardens are lower than from intensely managed improved variety rubber gardens, jungle rubber has several advantages which might not directly be obvious if looking at latex yield per hectare only. In times of decreasing primary forest, secondary vegetation and jungle rubber for large areas become the last refugium for primary forest species. This is the reason why jungle rubber is interesting for scientists, too. This chapter therefore will not focus on rubber garden management issues[15], but on its results, namely rubber garden biodiversity.

For that means the botanical composition of differently aged rubber gardens will be compared with undisturbed, mainly unmanaged, secondary vegetation of similar ages. This study has been carried through in three Sumatran villages, two in Jambi - Pemunyian and Dusun Birun - and one in West Sumatra Province - Lubuk Malakko. All villages are located at an altitude of approximately 350 m above sea level in the lowland boundary zone of the Kerinci-Seblat National Park. In each village inventories were made in a total of 14 to 16 different vegetation plots aged one to more than 60 years. Although only located 150 to 300 km apart from each others, the differences in botanical composition as well as total biodiversity of the village lands of the three villages is striking. For that reason, biodiversity and botanical composition comparisons have to be carried through first of all at the village level.

---

[15] For jungle rubber management issues : see Barlow 1982 & 1986, A Gouyon 1995, Penot 1997, Budiman et al 1994, and miscallanous publications from IRRI/BPS Sembawa.

3.1 Methodology

For the study of old secondary vegetation and rubber gardens, the quadrate (relevé) method has been applied. By this approach the relative role each species plays within the economy of the stand is investigated (de Rouw 1991). Reasons for different size of sample areas are generally based on the height and diameter of the vegetation of each age as well as on the amount of plant individuals per sample area. In young fallow plant communities up to the age of about 7 years the method of grid sampling was applied. Besides, the dominance of every plant is assessed in the sense of Braun-Blanquet. This approach seems to be more suitable to seize the structure of young secondary vegetation than the relevé method. Young secondary vegetation often is dominated by some few species, but the actual biodiversity might already be quite high, since many plants already start to occur with one or two individuals. Also the real dominance of each species might be better assessed to its real importance, because secondary vegetation often is heterogeneous, i.e. there are a lot of clusters of certain plants, caused by coppicing stumps and roots.

3.2 The influence of selective clearing on rubber garden composition and biodiversity

Each cycle of shifting cultivation initiates also a successional cycle of the fallow vegetation. Vegetation recovery starts already during rice cultivation and covers the whole field quickly after old upland fields are left open. During its development secondary vegetation proceeds through several stages. Every successional stage is characterized by a typical structure and plant composition which separates it from other stages. Nevertheless, there are much more factors influencing the composition of secondary vegetation than vegetation age. A major factor also is the cultivation history of a certain site, which determines the composition of the soil seed bank. Frequent burning destroys the seeds of those species being sensitive to burning. Short fallow cycles prevent the regeneration of those species having reproduction cycles exceeding those of the fallow length (Egler 1954, de Rouw 1991). Therefore plots which have been cultivated only a few times since they have been opened from primary forest have a higher biodiversity and a larger part of primary forest species than plots which have been cultivated frequently. Also soil fertility, which might vary with geomorphological position, has an influence on vegetation composition (Kellman 1980, Werner 1993). All these factors lead to the phenomenon that within the lands of one village vegetation composition and biodiversity of plots of the same age differ strongly.

If observing a large number of plots, many species occur related to a certain fallow age. This made it possible to identify plant families, genera and species typical for certain fallow stages. Other species, however, exhibit an unspecific behavior which cannot be related to a certain fallow stage. A large number of species also occurs too rarely to draw conclusions on their preferred fallow stage. Most part of these infrequent species, however, are supposed to be typical for old fallow or primary forest, because they only were present in old secondary vegetation, although only with some few individuals.

Differences in structure and composition of secondary vegetation and jungle rubber

Because of the magnitude of factors influencing fallow composition, comparing the plant composition of jungle rubber and unmanaged (or at least very extensively managed) secondary vegetation faces some difficulties. Nevertheless, in several cases a selective occurrence of species related to rubber gardens and secondary vegetation could be observed. First of all, however, we have to differentiate the several types of vegetation containing rubber in the study area. Here we have to refer again strongly to the management practices, because they are the most decisive factor determining the structure and composition of a rubber garden.

* *Unmanaged secondary vegetation containing rubber*

This type of vegetation almost cannot be defined as a rubber garden, because the difference to unmanaged secondary vegetation is not obscernable besides the very few scattered rubber trees existing (see Annex 1). Obviously the 'gardens' did not experience any management since the trees have been planted. In many cases mature rubber is not even tapped, especially if the plots are too far away from the village. Land ownership claims frequently is rather a reason for rubber planting in these cases than the intention to establish a rubber garden (cf. Gouyon *et al.* 1993, Dove 1993a). Penot also observed this kind of processes in areas where land has been allocated to large oil palm plantations, like in the Sanggau and Sintang areas in West Kalimantan as well as in the Muara Bungo area in Jambi. Sometimes, however, immature gardens are also abandoned due to rubber growth failures.

* *Regularly cleaned rubber gardens*

The vegetation types (or fallow stages) where differentiation between rubber gardens and undisturbed secondary growth was most obvious are those cases, where rubber gardens still were cleaned regularly. In young, cleaned rubber gardens of Dusun Birun, especially the total lack of the usually dominant pioneer tree *Macaranga* (EUPH) as well as *Pithecellobium* (LEG) was catching the eye. *Elaeocarpus palembanicus* (ELAEO), *Aporusa octandra* (EUPH) and *Ficus grossularioides* (MORA), species abundant in many plots of secondary vegetation of young to medium fallow age, also did not occur in the cleaned gardens. *Calophyllum canum* (CLUS), *Baccaurea sumatrana* (EUPH), *Koilodepas glanduligerum* (EUPH), *Lithocarpus urceolaris* (FAGA), *Casearia sp.* (FLAC), *Millettia atropurpurea* (LEG), *Pternandra sp.* (MELASTO) and *Artocarpus spp.*, all species frequent in medium to old secondary vegetation, could not be found in cleaned 15 and 20 year old rubber gardens, and they also occurred more rarely in older rubber gardens which were not cleaned anymore than in unmanaged old fallow of Dusun Birun. Other species only had a lower frequency in the cleaned rubber gardens, or occurred with a few individuals in some of them (see Annex 1).

These kind of rubber gardens probably cannot be classified anymore as 'enriched fallow' (Irvine 1985), because management has a had large impact on vegetation composition. In plots, where secondary regrowth was slashed every year, succession was 'frozen' in an early stage. In up to 25 year old regularly cleared rubber gardens, pioneer species and species of early succession still were abundant. Especially grasses, herbs and shrubs were not shaded out because the lack of undergrowth and a closed tree canopy. Some young rubber gardens had a dense undergrowth of vigorously growing ferns which had been favored by the altered succession process.

* *Old rubber gardens*

In most cases, rubber gardens are not cleaned anymore after they reach a certain age. At which age farmers stop slashing the undergrowth, lianas and unwanted spontaneous tree species depends a lot on the proximity of the garden to the village and the amount of time the family has available. When rubber gardens exceed the age of ten or, in certain plots close to the village sometimes twenty years, secondary growth usually is considered no more danger for rubber productivity. Within a few years, succession catches up. Plant composition and structure of old rubber gardens and old fallow

Table 4 Biodiversity and structural composition of the different vegetation types in the village land of Dusun Birun, Kec. Sungai Manau, Kab. Sarolangun-Bangko, Jambi province.

age	*plot no.*	*geo.. pos.* [1]	*utilisation*	*av. DBH (cm)*	*veg. height (m)*	*tree species*	*herbs & shrubs* [2]	*lianas*	*ferns*	*Grasses*	*palms*	*total species*
1	6	ls	fallow	1	1	12	12	9	2	3	-	38
2	12	s	fallow (r) [3]	2	2-3	17	7	6	2	4	-	36
3	9	f	rubber*	7	6	6	3	3	2	2	-	16
3	4	s	fallow	2.5	3-4	14	7	10	4	4	1	40
5	8	f	fallow	5-6	6-8	15	3	3	2	3	-	26
7	3	ls	rubber *	10	8	15	5	6	4	2	-	32
7	7	ls	fallow	5	6	29	3	3	3	1	1	40
7	15	s	fallow	8-10	6-7	28	8	6	2	2	1	47
10	11	s/t	fallow (r)	5	8	39	4	5	3	2	-	53
15	1	ls	rubber **	25	10-15	24	9	9	5	2	-	49
20	14	s	a) rubber, fruits b) cinnamon**	a) 40-50 b) 10-15	a) 7-15 b) 6	25	11	3	6	4	-	49
20	10	s	fallow (r)	25	30	47	5	10	1	1	2	66
25	2	s	rubber **	30-40	25-30	25	5	4	3	3	-	40
33	13	s	fallow	20	20-30	36	4	8	5	1	-	54
42	5	s	fallow	30	30	36	3	7	5	-	2	53
50	16	s	rubber ***	30	30	36	8	12	5	2	-	61

1 Geomorphological position: f = flat/level area, ls = lower slope, s= slope, t = hilltop.
2 Incl. bamboo and pandanus species
3 Some scattered rubber trees abundant.
* Rubber is not yet productive. Cleared regularly from weeds and secondary regrowth.
** Cleared regularly from weeds and secondary regrowth.
*** Not productive anymore (no more tapping since one or two years).

Table 5 Biodiversity and structural composition of the different vegetation types of the village land of Lubuk Malako, Kec. Sangir, Kab. Solok, West Sumatra.

age	*Plot No.*	*geo. pos.* [1]	*utilization*	*average DBH (cm)*	*veg. height (m)*	*tree species*	*herbs & shrubs*	*lianas*	*ferns*	*grasses*	*palms*	*total species*
20	7	l	rubber	25-30	20	28	9	5	3	3	-	48
20	11	t/s	fallow (r)[2]	20-25	20-25	67	2	13	6	2	3	93
65	9	l	rubber (fruits, coffee)[3]	35-40	25-35	20	5	7	6	2	-	40
65	10	t/s	rubber (fruits)	25-35	20-30	39	5	16	7	4	2	73

1 Geomorphological position: f = flat/level area, ls = lower slope, s= slope, t = hilltop.
2 This site has been used only once after primary forest has been cut down. Some scattered rubber trees abundant.
3 Because of low productivity due to the high age of the garden, rubber is not tapped anymore since about one year, whereas coffee is not cared for anymore since a long time. However, the coffee still bears some few fruits which are collected by children.

therefore becomes very similar (see Annex 1; cf. Gouyon *et al.* 1993). Nevertheless, in some cases the abundance of certain species is lower than in unmanaged old fallow, because they need time to establish themselves after cleaning has ceased. In cases where only some few tree individuals of a certain species have been available in the soil seed bank at the end of the rice cultivation period, there might be no more viable seeds available once cleaning was stopped. Also species which cannot resprout from stumps after they got slashed might lack in old rubber gardens.

Jungle rubber and secondary vegetation biodiversity compared

The impact of management practices on the botanical composition of rubber gardens compared to undisturbed secondary vegetation also reflects itself in plot biodiversity. This has been obvious in Dusun Birun. A three-year regularly cleaned old rubber garden had a total biodiversity of 16 species, six of which were trees (table 4). Secondary vegetation of the same age had an almost two times higher biodiversity, namely 40 species, among them ten tree species.

The same feature could be observed within seven year old regularly cleaned rubber gardens. The cleaned garden had a biodiversity of 32 species, whereas the two fallow sites harbored 40 and 47 species. More distinct become the differences when looking at tree species diversity. In the cleaned garden only 15 tree species were abundant, whereas in the secondary vegetation 29 and 28 tree species could be found. Also 15, 20 and 25 old rubber gardens, which still had been cleaned once in a while exhibited a much lower biodiversity, especially concerning tree species, than undisturbed secondary vegetation of similar age (table 4).

Like the botanical composition, also biodiversity is influenced by various factors, leading to a wide variation in biodiversity of plots of the same age. A good example for how much the history of a plot influences its biodiversity are two 20-year old sites in Lubuk Malakko. The one has been only cultivated once since it was opened from primary forest, planted to rubber, but never cleaned. The other is a well-managed rubber garden. The first one has a total biodiversity of 93 species, 67 of them trees, whereas the second only has about half of the biodiversity, 48 species, 28 of it trees (table 2). In this case, however, besides the cleaning of the rubber garden, the fact, that one site only has had been cultivated once, and the other more frequent, was influencing on biodiversity. This feature is related to the "all-importance of the pre-existing seed bank (de Rouw 1991: 222), which is strongly related to the cultural history of the site.

Another rubber gardens in the same village also demonstrate the influence of management practices. The garden partly is located on a hill, partly on flat land and about 65 years old. The lowland part had been mixed with coffee, the upland part hadn't. I made one plot à 20 x 50 m in each part of the garden. Surprisingly, the biodiversity of the lowland plot was only about half of the upland one, a total of 40 species, 20 of them trees versus 73 species, including 39 trees (table 5). The undergrowth of the lowland plot, however, was strongly dominated by coffee seedlings. I estimated a number of about 1,000 saplings within a 10 x 10 meters square. Although the coffee was not managed anymore, this plot certainly had been cleaned longer than the uphill rubber garden with no coffee, influencing biodiversity. After being left fallow, the high abundance of coffee undergrowth might also have prevented tree regrowth to a certain extent.

Finally, the rubber gardens of Pemunyian are a good example for the increase in biodiversity, after the cleaning of the garden had ended. Both the 20 and the 60 year-old rubber gardens showed no more sign of former clearing measures. Resultingly, site biodiversity steadily increases with age.

Table 6 Biodiversity and structural composition of the different vegetation types of the village land of Pemunyian, Kec. Tanah Tumbuh, Kab. Bungo Tebo, Jambi.

Age	*Plot No.*	*geo. pos.*[1]	*utilisation*	*av. DBH*	*veg. height*	*tree species*	*herbs & shrubs*[2]	*lianas*	*Ferns*	*Grasses*	*palms (incl. rattan)*	*total no. of species*
15	10	f	fallow	25	15	22	-	2	1	2	-	27
15/20	11	t-s	fallow	25	25	36	2	9	1	1	2	51
20	5	f	rubber	25	25	41	2	8	2	1	1	55
20	8	f-ls	rubber	30	20	31	5	7	3	-	2	48
36	15	t-s	fallow	30	35	39	2	7	6	-	2	56
60	6	s	rubber	35	25	41	4	8	4	1	3	61
60	9	s	rubber	40	35	32	4	9	3	-	2	50
60	16	f	rubber	30	30	47	6	15	1	1	3	73

[1] Geomorphological position: f = flat/level area, ls = lower slope, s= slope, t = hilltop·
[2] Incl. bamboo and pandanus

both if comparing rubber gardens among each others as well as if comparing them to undisturbed fallow vegetation (table 6).

3.4 Conclusions on biodiversity comparison between rubber agroforests and secondary forest in Jambi and West Sumatra

Secondary regrowth has been investigated within secondary vegetation, which was only left fallow after shifting cultivation, and within those, where rubber has been planted into the maturing rice field and which has been cleared regularly in the years after. Management practices are very important for the course of succession and alter it significantly. Because undesired species are cut and weeded out, Irvine (1985) calls this kind of interventions into the natural course of fallow development a 'guided succession'.

The chapter above showed, that regular selective cleaning practices are the major reason for differences in botanical composition and biodiversity of rubber gardens and unmanaged fallow. This could be proved by comparing secondary vegetation with fallow planted to rubber but unmanaged, regularly cleaned gardens and old jungle rubber which was not cleaned anymore. Uncleaned rubber gardens merely experienced an enrichment planting, resulting in 'secondary vegetation with rubber' (an ecological definition initially used for mapping by Y Laumonier). Besides of some scattered rubber trees, few differences to unmanaged fallow could be observed.

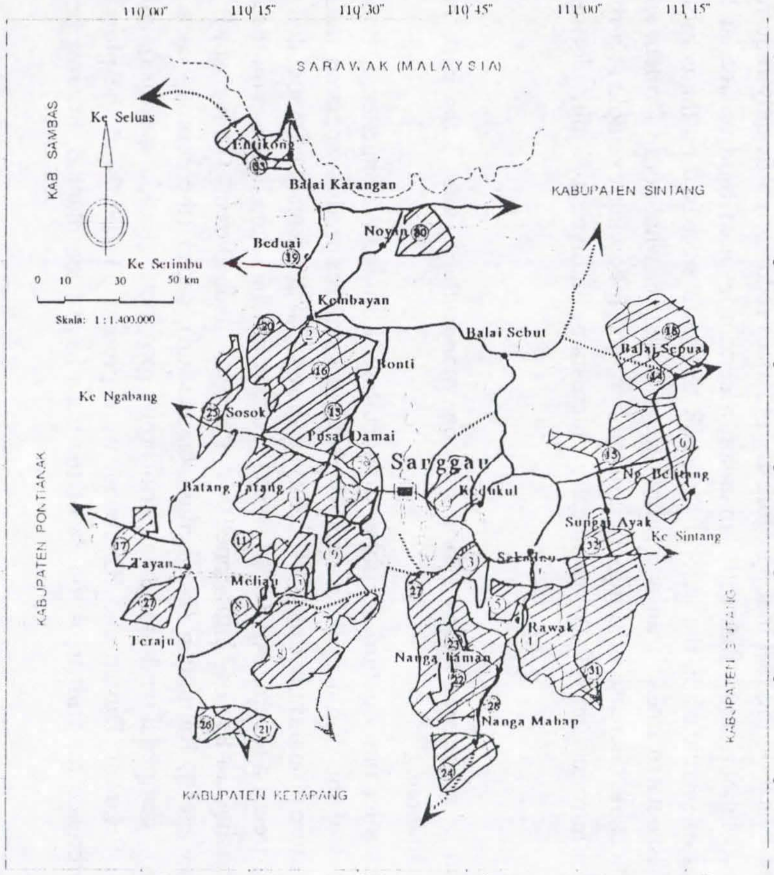
Gardens intended for future use usually employ regular weeding during the immature period as well as selective cutting of vegetation to favor economically interesting trees. Systems managed by these measures may be defined as rubber agroforestry systems, not anymore as enriched forests. This approach has been further developed through SRAP with the introduction of innovations (Penot 1997) as planting in line and use of round-up the first year to control Imperata. After cleaning measures were stopped, forest biodiversity in old rubber gardens develops towards secondary vegetation levels and composition when succession is allowed to catch up. The longer a garden is not cleaned anymore, the more biodiversity equals those of uncleared fallow locations.

Improved RAS are based on the fact that agroforestry practices reduce significantly requirements in terms of inputs and labour, and , indirectly, maintain a certain level of biodiversity, at least very comparable to that of secondary in the case of RAS1. RAS 2 & 3 are based on the combination of rubber and other associated trees , fruit and timber trees, based on what some farmers are already doing without noticeable decrease of production of rubber. The following example is a remarkable case study of re introduction of "economically interesting biodiversity" into former rubber monoculture plots.

The re-introduction of associated trees in former rubber monoculture plots : the case of Sanjan village in West Kalimantan.

In Sanjan, 13 years after introduction of rubber monoculture, a study (W. Shueller, E Penot, 1997) showed that 15 out of the original 50 farmers (30 %) have reintroduced associated trees in their originally monoculture clonal rubber plots. The survey shows that the density of associated trees was between 94 to 291 trees/ha (average of 167) for 500 rubber trees /ha with emphasis on the following species by decreasing order of importance : Pekawai and Durian (Durio spp) , Belian (Euxyderoxylon zwageri), Rambutan (Nephelium lappaceum), cacao (theobroma cacao), assam (Tamaridus indica) , cempedak and mentawa (Artocarpus spp), petai (Parkia speciosa), and Nyatoh (Pallaquium spp). Pekawai, Durian and Rambutan were present on 100 % of the plots. Farmers express a net preference for fruit trees. 64 % of the trees have been planted, the rest being from

1 PETA PERKEBUNAN DI KABUPATEN DATI II SANGGAU



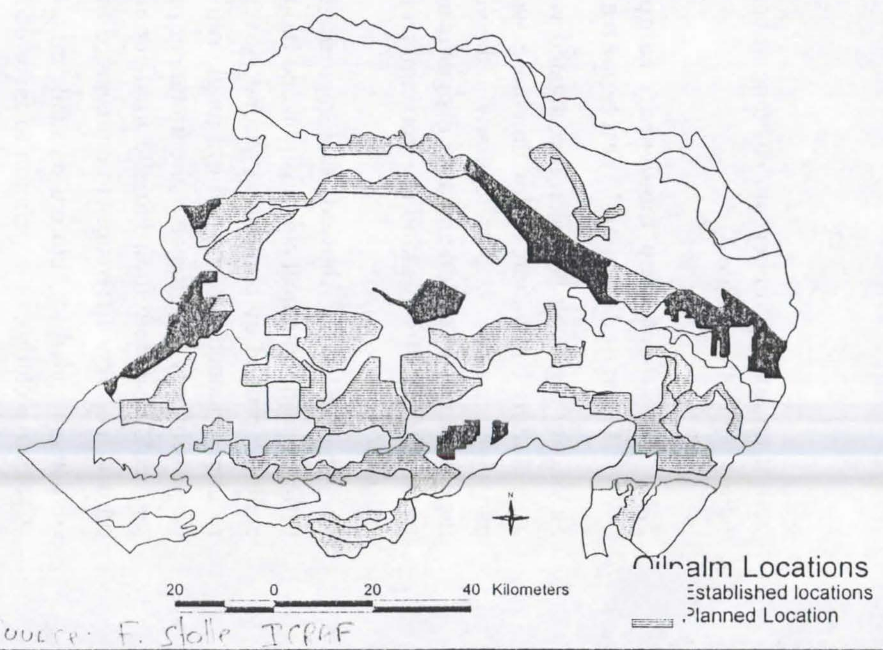
Keterangan :

- Batas Negara
- Batas Kabupaten
- Batas Kecamatan
- Sungai
- Ibukota Kabupaten
- Ibukota Kecamatan

Areal Perkebunan

- (A) Sudah Beroperasi dan Berproduksi
- (B) Sedang Operasi (Penanaman / Izin Lokasi)
- (C) Akan Beroperasi (Pengarahan Lahan)

2 District Bungotebo, Planned Oilpalm locations



Source: F. Stolle ICRAF

natural vegetation regrowth and selection. We do not know to which extend this case study can be generalized but it is clear that for some Dayaks farmers, income diversification and reintroduction of an economically interesting biodiversity in former monoculture are part of their strategies.

4 Fires, land-use and CAF : a scope for RAS

Originally being part of the shifting cycle, RAS also are initiated by slash and burn, even improved RAS. Under the larger climatic conditions of El Nino, however, prolonged dry seasons occur every few years in Southeast Asia, frequently supporting the spread of local burning into large-scale forest fires. The problem of fires and consequent deforestation has been front page news in every drought year in the last 15 years, and in particular in 1982/83, 1987, 1991, 1994 and, with its huge haze problem, again in 1997. Estimation of deforestation and burned areas (table 7 & fig 6) are varying from 100 000 ha (Ministry of Forestry) to 3 million hectare which is the most probable figure calculated after remote sensing imagery (Y Laumonier, personal comm.). Because the government perceives shifting cultivation as backwards and unproductive, forest fires have always provided a good reason to hit out at shifting cultivators and blaming them for the fires. Nevertheless, slash and burn practices are also applied by spontaneous migrants, government-resettled transmigrants and, on a larger scale, plantation companies for opening their land. Also if observing the history of forest fires, they only started to blaze over large areas since the early 1980s. This is about the time when logging companies accelerated their operations in the world's second-largest rainforest reserves in Sumatra and Kalimantan. Being no coincidence, there is a clear relationship between the spread of logging, commercial timber and oil palm estates and the occurrence of large scale forest fires.

Related to the role of shifting cultivators in forest destruction, it is also becoming clear that deforestation by smallholders has been over-estimated for the 1980's (Sunderlin and Resosudarmo 1996). In 1990, the World Bank estimated the annual rate of deforestation between 700,000 and 1,200,000 ha with between 350,000 and 650,000 ha only from smallholders which represents more than 50 %. Referring to the work of Dick (1991), it seems that 67 % of all deforestation comes from government sponsored programs (transmigration, estates crops, logging). The real contribution in deforestation is probably inferior to that in 1997. The maps number 1 & 2 show that the land allocation process in the very next future is cleraly estate oriented and will not let very much room for local systems.

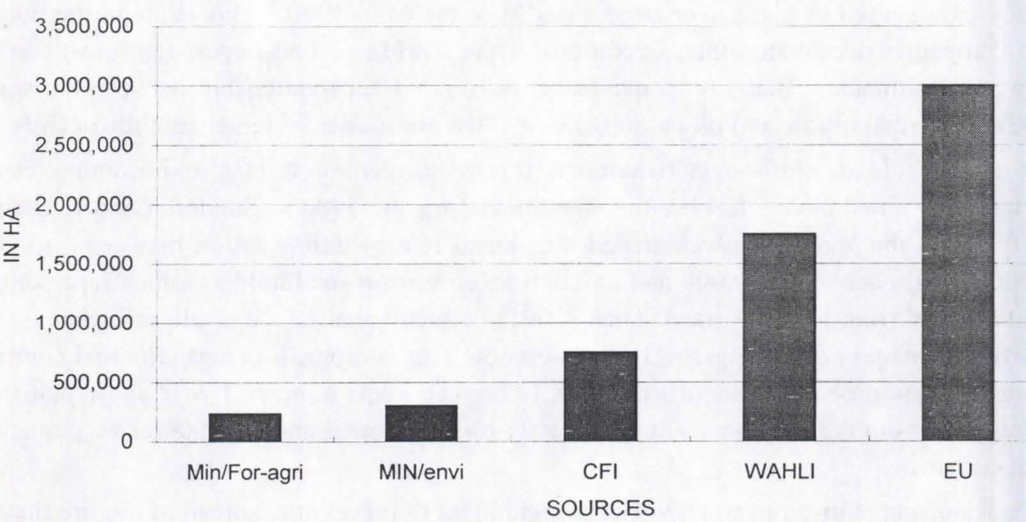
Traditional shifting cultivators employ special techniques to prevent the spread of the fire they use to burn their future upland field to ascendant plots. They do so by cutting the trees in such a way so they fall into the area to be burned. Then the plot is to be burned with the wind direction, to control the spread of the fire. When Werner attended the opening of a large upland field to be used by several families in Sanjan village, West Kalimantan, she observed that the fire stopped at the fringes of the field and did not enter adjoining forest gardens. When local migrants enter logged forest along the logging roads to open commercial plantations, however, burning might spread beyond the future field. This is due to the reason that these farmers do not originate from a shifting cultivation background, so they may not have the traditional knowledge how to control the fire. Furthermore, logging roads represent excellent wind-channels, blowing the fires deep into the forests, while the fires feed on dry brush and bark along the roadsides. The same is even more true for plantation companies, burning large areas for the establishment of fast-growing timber (pulp & paper) and palm oil estates, especially because many estates are located within former conversion forest bordering production forest. Concerning the 1997 fires most of the fires could be located in areas

7

STATEMENT OF BURNED AREAS BY FIRES IN 1997 by various sources

Source of information By type of land use	CODE	BURNED AREAS ha
Ministry of forest		
Total forest	forest	96,000
Timber estates	timber	15,000
Ministry of agriculture		
Plantations	plantations	121,626
Total official ministries	Min/For-agri	232,626
Ministry of environment	MIN/envi	300,000
CFI	CFI	750,000
Indonesian Forum for Environment	WAHLI	1,750,000
Y Laumonier EU/FIPM	EU	3,000,000

6 ESTIMATION OF BURNED FOREST IN 1997 BY VARIOUS SOURCES



newly allocated to estates, in particular for oil palm and *Acacia mangium* pulp and paper plantations.

According to Laumonier (EU-FIMP project, personal comm. 1997), it seems that only a crude estimate of 300 000 ha out of 1 million ha that burned in South Sumatra and Lampung were covered by forest, whatever types. In other words, forest, primary or old secondary forest, as well as forest-like environments such as CAF do not burn easily, at least when mature. It s true that CAF in early stages are still fragile systems susceptible to fire damage. But the promotion of RAS and other CAF is another way to reduce fire risks, in particular in degraded areas such *as Imperata* grasslands where these CAF can also be considered as very reliable alternative for land rehabilitation (Penot 1995, De Foresta and Michon 1997). Besides a lower inflammability of RAS compared to young secondary vegetation or large oil palm or pulp and paper plantations, farmers will also provide for fire control to protect their CAF, if opening new fields nearby.

5. Conclusions

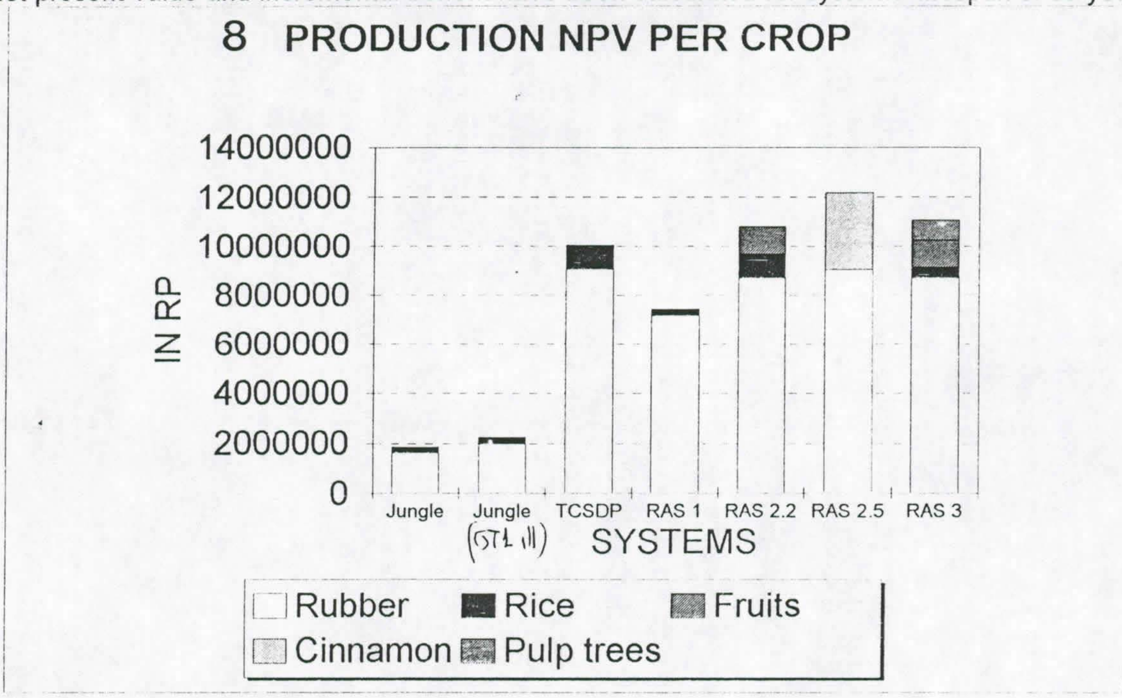
As long as forests still covered vast areas of Sumatra and Kalimantan, there was no need to think about the value of biodiversity within CAF. Since the 1980s, however not only primary, but also older secondary forests are disappearing at an alarming rate to become replaced by large scale plantations. With government policies focusing at the intensification of local agriculture towards monocultures and very limited mixed cropping systems, there seems to be little scope for forest biodiversity to survive outside protected areas. Under conditions where even in protected areas forests are not save from conversion and illegal logging, and lowland forests at least in Sumatra have almost vanished, this is a threatening development. There are, however, possibilities to conserve a certain level of biodiversity by integrating it into improved cropping systems with high returns such as CAF and in particular RAS.

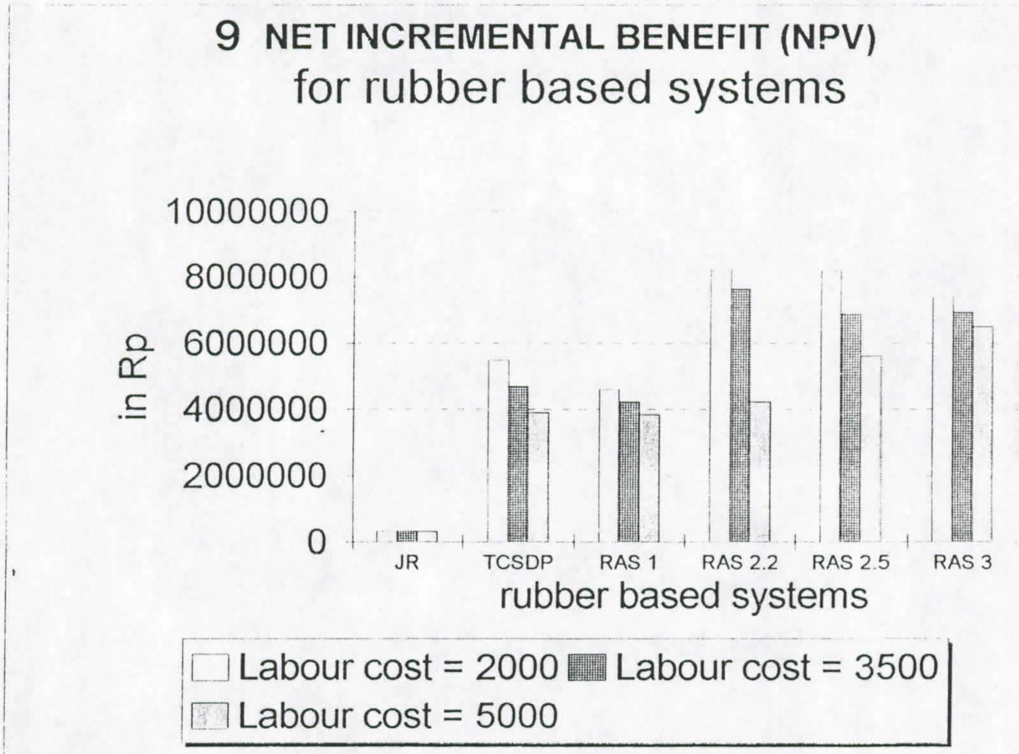
Conserving biodiversity within cropping systems, frankly speaking, is nothing but old wine in new bottles. Scientists did not discover this possibility, it was there all the time in traditional CAF all over the Indonesia. The new approach within RAS, however, is the integration of high-yielding varieties into traditional management systems, and to modify management in such a way, that both yields and returns-to-labor are optimized. Biodiversity in form of spontaneous secondary regrowth still is a side-product of this system, but the farmers ability is being recognized and supported to select the spontaneous biodiversity into 'economically interesting biodiversity', a fact that has been mainly overlooked by agriculturalists when disregarding traditional jungle rubber.

Rubber agroforests certainly cannot preserve all forest biodiversity, especially when it comes to primary forests. Comparisons between secondary forests and rubber gardens, however, show that old jungle rubber which has not been cleaned for several years has a biodiversity and species composition similar to old secondary forest. In this perspective, it seems clear that CAF and in particular highly productive RAS represent economically and ecologically sustainable cropping systems for smallholders. Furthermore RAS offer a refugium for part of the forest biodiversity as a complement to existing conservation areas. The potential land size to be converted from old rubber agroforest into RAS is, at least, covering 800,000 ha in Sumatra (roughly assessed by A Gouyon in 1990) and probably as much as 150,000 ha in West Kalimantan (Penot, 1997, personnal assessment). RAS are economically interesting and very similar for RAS 1, and even better for RAS 2 & 3, in terms of benefit as shown in figure 8 & 9 (net present value of production and incremental benefit compared to that of jungle rubber). Improved RAS appear as one potential sustainable alternative to both productivity and biodiversity maintenance.

ECONOMIC ANALYSIS AND COMPARISON BETWEEN RUBBER AGROFORESTS, RUBBER MONOCULTURE (TCSDP) , AND RAS (Rubber Agroforestry Systems)

Net present value and incremental benefit have been calculated for systems' lifespan of 35 year





Source , Penot , 1996.

References

Barlow C and Muharminto, 1982a. The rubber smallholder economy. *Bulletin of Indonesian Economic Studies*, Vol XVIIII, 2, 1982.

________, 1982b. *Smallholders rubber in South-Sumatra, towards economic improvement.* Balai Penelitian Perkebunan Bogor, Australian National University.

Barlow C and SK Jayasurija, 1986. Stages of development in smallholder tree crop agriculture. *Development and Change* 17: 635-658.

Barlow C and T Tomich, 1991. Indonesian agricultural development: The awkward case of smallholder tree crops. *Bulletin of Indonesian Economic Studies* 27 (2): 29-53.

Booth A, 1988. *Agricultural development in Indonesia.* Asian Studies Association of Australia, Southeast Asia Publications Series No. 16, Allen & Unwin, Sydney, Australia.

Cotrell A, Undang Fadjar, Sulfoni Arifin, and J Western, 1988. *Socioeconomic factors and the adoption of new technologies: rubber smallholders in South Sumatra.* BPS and Queensland University.

Courbet P, E Penot and Ir Hilahang, 1997. *Farming system characterization and innovations adoption process in West-Kalimantan.* Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia

De Foresta H, 1991. *Fieldtrip to BPP Sembawa.* ORSTOM/BIOTROP.

________, 1992a. Complex agroforestry systems and conservation of biological diversity: for a larger use of traditionnal agroforestry trees as timber in Indonesia, a link between environmental conservation and economic development. Golden Jubilee issue. *Malayan Nature Journal.* Proceedings of the International conference on the conservation of tropical biodiversity.

________, 1992b. *Botany contribution to the understanding of smallholder rubber plantations in Indonesia: an example from South-Sumatra.* Symposium "Sumatera Lingkungan dan Pembangunan". Bogor, 1992.

________ and G Michon, 1995. The agroforest alternative to Imperata grasslands: when smallholder agriculture and forestry reach sustainability. To be published in: *Agroforestry Systems.* Bogor, Indonesia. (ALREADY PUBLISHED? 1995!!)

________, 1997. *Smallholder rubber plantations viewed through forest ecologist glasses.* An exemple from South Sumatra. Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia .

De Jong Will. The riches of the forests : use potential and economic returns from Dayak managed forests. Quarterly reports. 1992, 1993 & 1994. Dayak forest management research project, LIPI/University of Tanjungpura, Pontianak, Indonésia.

_______, Deforestation and reforestation in a Dayak village in West Kalimantan. 3rd Biennal International conférence of the Borneo Research Coucil. New york Botanical Garden. Pontianak, Indonésia, 1994.

_______, Recreating the forest : successful examples of etho conservation among land-Dayaks in central West Kalimantan. Paper presented at the internationl Symposium on management of tropical forests in Southeast Asia. Oslo, 1994.

DGE. 1993. *Statistik karet.* Jakarta, Indonesia: Ministry of Agriculture.

Dijkman MJ, 1951. *Hevea : 30 years of research in the far-east.* University of Miami Press..

Dove MR, 1983. Theories of swidden agriculture, and the political economy of ignorance. *Agroforestry systems* 1: 85-99.

_______, 1985. Plantation development in West Kalimantan I: Extant population / labor balances. *Borneo Research Bulletin* 17 (2): 95-105),

_______, 1986. Plantation development in West Kalimantan II: The perception of the indigenous population. *Borneo Research Bulletin* 18 (1): 3-27.

________, 1993a. Smallholder rubber and swidden agriculture in Borneo: A sustainable adaptation to the ecology and economy of the tropical forest. *Economic Botany* 47 (2): 136-147.

_______, 1993b. A revisionist view of tropical deforestation and development. In: *Environmental Conservation*, Vol. 20: 17 - 24.

_______, 1995 Political Versus factors in the development of non timber forests product: lessons from a comparison of natural and cultivated rubbers in Southeast Asia (and South America). Society and natural resources. Vol 8, p193_208

Egler FE, 1954. Vegetation science concepts. 1. Initial floristic composition, a factor in old-field vegetation development. *Vegetatio.* Acta Geobotanica. Vol. 6, 1.12, Fasc.6: 412-417. Den Haag.

Gouyon A, 1993a. Entre forêt et plantations, imaginer un avenir pour les forêts à hévéa indonésiennes. *Bulletin Arbres, Forêts et Communeautés Rurales*, 1993.

________ , De Foresta and P Levang, 1993. Does 'jungle rubber' deserve its name? An analysis of rubber agroforestry systems in southeast Sumatra. *Agroforestry Systems* 22: 181-206.

________ , 1993b. Les plaines de Sumatra-Sud: de la forêt aux hévéas. *Revue Tiers-monde*, XXXVI, no. 135.

________ , 1993c. *De la forêt à hévéas aux usines d'Akron: une production paysanne pour un marché industriel.* Communication au groupe "avenir des zones troicales humides", Réseau Recherche-Développement. CFD. Paris. 1993.

________ , 1995. *Paysannerie et hévéaculture: dans les plaines orientales de Sumatra : quel avenir poutr les systèmes agroforestiers?*. Thése INA-PG. INA-PG, Paris.

ICRAF, 1995. *Alternatives to slash and burn in Indonesia*. Annual report. Bogor. 1995.

Irvine D, 1985. *Succession management and resource distribution in an Amazon rainforest*. Paper presented, meeting of the American Anthropological Association, Washington D.C.

Kellman M, 1980, Geographic patterning in tropical weed communities and early secondary succession. *Biotropica*, Suppl. Vol. 12, No. 2: 34-39.

Kelfoun A, E Penot and Iwan K, 1997. *Farming system characterization and innovations adoption process in Jambi* . Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia

Keowvongsri Pramoth. Les jardins a hévéas des contrforts orientaux de Bukit bariaan, Sumatra, Indonésie. Mémoire DEA botanique tropicale appliquée. USTL, Montpellier, France, 1990.

Michon G and H De Foresta, 1990. Complex agrogorestry systems and conservation of biological diversity : agroforestry in Indonesia, a link between two worlds.. Golden Jubilee Issue. *Malayan Nature Journal*. Proceedings of the 'International conference on the conservation of tropical biodiversity', Kuala Lumpur.

________ , 1991. *Agroforesteries indonésiennes: systèmes et approches*. Atelier "Quelle agroforesterie pour l'ORSTOM ?", Paris.

________ and N Wijanyanto, 1992. *Complex agroforestry systems in Sumatra*. Symposium "Sumatera Lingkungan dan Pembangunan". Bogor, 1992.

________ 1995. The indonesian agroforest model. Forest ressources management and biodiversity conservation. In: *Concerning biodiversity outside protected areas: The role of traditional agro-ecosystems*; P Halladay and D Gilmour (eds). IUCN/AMA.

Momberg F. Indigenous knowledge systems. Potentials for social forestry development. Ressource management of land-Dayaks in West Kalimantan. Techniwhe Universitat Berlin. 1993, Germany.

Noordwick M van, van Shaick, H de Foresta and T Tomich, 1995. *Segregate or integrate nature and agriculture for biodiversity conservation*. ICRAF, Duke University, ORSTOM. Paper presented at the Biodiversity Forum, November 1995, Jakarta.

Penot E, 1994. *Improving the productivity of smallholder rubber agroforestry systems: sustainables alternatives*. Project frame, general proposals and On-Farm-Trial methodology. Working paper. Presented at ICRAF, 15 September 1994.

________ , 1995 Taking the jungle out of rubber. Improving rubber in indonesian agroforestry systems. *Agroforestry Today*, July/December 1995.

________ , 1996a. *Sustainability through productivity improvement of Indonesian rubber based agroforestry systems*. Paper presented at the14th international symposium on sustainable farming systems. Colombo, Sri Lanka. November 1996.

________ , 1996b. *Improving productivity in rubber based agroforestry systems (RAS) in Indonesia: a financial analysis of RAS systems*. Paper presented at the GAPKINDO seminar in Sipirok, 27-29 March 1996, North-Sumatra.

________ , 1997a. *From shifting agriculture to sustainable rubber complex agroforestry systems (jungle rubber) in Indonesia: an history of innovations production and adoption process*. Paper presented to the ICRAF/Cornell University workshop on 'Indigeneous strategies for the intensification of shifting cultivation in Southeast Asia'. June 1997.

________ , 1997b. From shifting agriculture to sustainable rubber complex agroforestry systems (jungle rubber) in the peneplains of Sumatra and Kalimantan in Indonesia: innovations in local rubber based cropping systems. Contribution to the World Bank report: Indonesia: upland agricultural technology study; F Ruf and F Lancon (eds.). CIRAD, February and November 1997.

________ , 1997c. *Introduction to SRAP methodology and concepts: summary of the preliminary results*. Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia.

________, 1997d. *L'amélioration des agroforets à hévéa : un enjeu pour 1 millions de paysans en Indonésie*. Published in CIRAD-CP PRD publication. December 1997, Montpellier.

Penot E and A Gouyon, 1995. *Agroforêt et plantations clonales: des choix pour l'avenir.* Presented at the seminar of CIRAD-MES, September 1995.

Penot E and G Wibawa, 1996. *Improved Rubber Agroforestry Systems in Indonesia : an alternative to low productivity of jungle rubber conserving agroforestry pratices and benefits. First results from on-farm experimentation in West-Kalimantan.* Paper presented at the IRRDB annual meeting, Beruwala, Sri Lanka, November 1996. (IRRDB = International Rubber Research and Development board)

________, 1997. *Preliminary conclusion summary paper of the SRAP workshop on Rubber Agroforestry systems.* Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia

Rouw, A. de, 1991. *Rice, weeds and shifting cultivation in a tropical rainforest. A study of vegetation dynamics.* Doctoral thesis. Paris.

Ruf F. Stratification sociale en économie de plantation ivorienne. Thése de Doctorat. Université Paris X. CIRAD, Montpellier, France, 1988.

Sunderlin W.D & Resosudarmo I.A.P, Rates and causes of deforestation in Indonesia; towards a resolution of ambiguities. CIFOR ocasional paper n° 9, Bogor, Indonesia, 1996.

Stolle F, 1997. *Land use in Jambi province in Sumatra: an overview.* Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia

Thiollay JM, 1995. The role of traditionnal agroforests in the conservation of rain forest bird diversity in Sumatra. *Conservation biology*, vol 19, n° 2.

Shueller W, E Penot, Ir Sunaryo, 1997. *Rubber Improved Genetic Planting Material (IGPM) availability and use by smallholders in West-Kalimantan Province.* Paper presented at the SRAP workshop on R.A.S. (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia

Werner S, 1993. *Traditional land use systems of Dayaks in West Kalimantan, Indonesia: Ecological balance or resource destruction? A study of vegetation dynamics and soil development.* Unpublished M.Sc.-Thesis, Institut of Geography, Free University of Berlin.

________, 1997. *The development of Central Sumatran traditional fallow systems in a changing environment.* Paper presented at at the 'Regional Workshop on Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia', Bogor, 23-27. 6. 1997. Proceedings forthcoming.

Annex 1: Abundance of tree-species according to fallow age in secondary vegetation and rubber gardens of Dusun Birun, Kec. Sungai Manau, Kab. Sarolangun-Bangko, Jambi, Sumatra

1

Number of the vegetation-plot	6	12	9	4	8	3	7	15	11	1	14	10	2	13	5	16
age of the vegetation-plot	1	2	3	3	5	7	7	7	10	15	20[17]	20	25	33	42	50
Abundance of rubber		o	x			x			o	x	x	o	x	x		x
Geomorphological position[18]	ls	ls	f	s	f	ls	ls	ls	s/t	s	f/s	f/s	s	s	s	s

---

[17] 20 year old jungle rubber, cleared, with 1-5 year old cinnamom in the understory.

[18] f = flat/level area, ls = lower slope, s= slope, t = hilltop.

2

No. Coll	botanical name	local name	1	2	3	3	5	7	7	7	10	15	20	20	25	33	42	50	Main occurrence[19]
248	Endospermum diadenum EUPH	nengok kerbau	o		+ + +	o													1
253	Ficus variegata MORA	kayu aro		o		o													1
242	Trema orientalis ULMA	menarung		+		+													1
247	Macaranga sp. EUPH	balek angin	+ +	+ + +		+ + + +	+ +		o	o			o						1 (2)
240	Alstonia scholaris APOCY	pulai	o		o			o			o			o					1-2
154	Macaranga gigantea EUPH	cikubung		+ +		o	+			+ +	+	+				o			1-2
308	Pithecellobium bubalinum LEG	jaring tupai merah		o			+ +		+	+ +								o	1-2
152	Pithecellobium cf. jiringa LEG	jering	+	o			+ +		o			+	o	o					1-2
258	Ficus grossu-larioides MORA	semantung belukar		+		o			o		o							o	1-2
177	Macaranga hullettii EUPH	kayu tima merah		+			+ +	o	+	+ +	+ +	+		+		o	o	o	(1) 2 (3)
239 309	Arthrophyllum javanicum ARALIA	surin belukar						o	o	o	o								2
307	Macaranga cf. nicopina EUPH	lalok akar					+ + +		+	+	+ +								2
319	Commersonia bartrama STERC	nilauruso					+			+ +									2
201 (2) 217 290	Vitex cf. gamose-pala VERB	kayu kenidai badak							o	o					+		o		2 (3)
153	Campnosperma auriculatum ANACARD	terentang					+	+		o	+	o		o	o	+		o	2-3
207 (1)	Callophyllum canum CLUS	setinjau belukar								+	+			+	o	o	+	+	2-3
198	Baccaurea cf. sumatrana EUPH	kayu tanah									+			+	+		+	+	2-3
271/ 283	Koilodepas glanduligerum EUPH	gerumbung							+ +		+ + +			+			+	+	2-3
155	Macaranga hypolinca EUPH	kayu tima putih				o			+	o		+		o	+	+ + + +		+	2-3
203	Lithocarpus urceolaris FAGA	mempening				o			o	o	+			o	o		+	+	2-3
200	Casearia sp. FLAC	kayu kajut						o		+	o			o	+		+	+	2-3

[19] Site specific abundance of the species: Species is typical for
1 young secondary vegetation (1-5/7 years)
2 medium aged secondary vegetation (5/7-15/20 years)
3 old secondary vegetation (> 15 years)

No. Coll	botanical name	local name	1	2	3	3	5	7	7	7	10	15	20	20	25	33	42	50	Main occurrence[19]
218	Dialium sp. LEG	jaring tupai putih							+		+ +		o	o	o	o	+	+	2-3
223	Millettia atro-purpurea LEG	mibung						o		+				+ +		o	+		2-3
209	Pithecellobium clypearia LEG	petei lalang		o					o	o	o			o	o	o		o	2-3
182 (1)	Pternandra sp. MELASTO	kayu ubi						o	+	+	+ +	o		o	+	+ +	+ + +	+ + +	2-3
182 (2)	Dissochaeta gracilis MELASTO	kayu ubi																+	2-3
206	Artocarpus cf. kemando MORA	cimeda mcit							+ +	o	+			o	o	o	+	o	2-3
264	Artocąrpus elasticus MORA	terap nasi					o		o	o	+			o			+ +	+	2-3
313	Artocarpus elasticus MORA	terap api							o	+ +	o			+ +		o		o	2-3
282	Horsfieldia ma-juscula MYR!S	manarin									o			o			o		2-3
208	Gardenia tubifera RUBI	pauh-pauh	o					o	o		o			+ +	o	o	o	o	2-3
162 252	Psychotria viridiflora RUBI	bunga telor ikan, kayu segumpal				o	o			o	+ +	o	o	o		o	o	+	2-3
204	Tarenna cf. buru-ensis RUBI	jambu rimba									+			o	o	o			2-3
156	Styrax benzoin STYRAC	kayu kijang					o			o	+	o			o	+ + +	+		2-3
199	Cyathocalyx sp. ANNO	antoi babi							+						+	o	+		(2) 3
277	ANNO	antoi belukar									o			+ +		+	o	o	3
151	Parkia speciosa LEG	petei										+			+			o	3
276 337 359	Discocalyx sp. MYRSIN	kayu pasak merah (2), lidah-lidah												o		o	o		3

no shading vegetation contains no rubber and is relatively unmanaged
light shading vegetation contains rubber but is relatively unmanaged, rubber is not tapped.
dark shading regularly cleaned rubber gardens

Table 3 Differences in density, species richness, and composition as a function of cultivation history.

	Trees > 5 cm dbh		Stems > 50 cm height		
sample area	4 plots 25m x 30m per site (.30 ha/site)		12 plots 5 m2 per site (60 m2/site)		
cultivation history					
Primary forest	357 stems		178 stems		
	144 species		89 species		
			lianas	11	
			ferns	1	
			herbs	2	
			rotans/palms	5	
			trees/shrubs	69	
10-year old forest cultivated twice	317 stems		211 stems		
	24 species		39 species		
			lianas	2	
			ferns	6	
			herbs	5	
			rotans/palms	0	
			trees/shrubs	26	
10-year old forest cultivated many times	430 stems	without bamboo 313 stems	245 stems		without bamboo 178 stems
	18 species	17 species	33 species		32 species
			lianas	6	
			ferns	2	
			herbs	3	
			rotans/palms	0	
			trees/shrubs	22	

TABLE 4

MAIN CHARACTERISTICS OF TREES ASSOCIATED TO RUBBER IN RAS

TREE	USE spice	gums resins latex	textile	wood TIMBÊR	fruits or nuts	sugar products	medicinal or insecticid	stimulant	craft	legumes	oleaginous	tanins and colonferous	perfum	ornemental	miscelanous fooder firewood cover-crop	environement oriented
PETAI	X			X			X			X					X	
CEMPEDAK			X	X	X		X			X					X	
PETAWAI																
KERANGI				X	X											
BEDARA				X	X		X	X			X					
TERAP		X	X	X	X		X		X		X					
PANDAN WANGI									X				X			
PANDAN PUNDAK			X		X		X		X	X				X		
DUKU				X	X		X					X				
RAMBUTAN				X	X		X	X			X					
MERANTI/DAMAR		X		X			X					X				
TANGKIL			X	X	X					X						
JENGKOL			X				X			X		X			X	
SUNGKAI				X			X							X		
TEK/JATI				X			X									
MAHONI/MAHOGANY		X		X			X									
GLIRICIDIA														X	X	X
LEUCEANA							X	X		X		X			X	X
GAHARU			X	X			X						X			
CULTIVATED RATTAN									X							
RATTAN MANAU									X							
ACACIA MANGIUM															X	X
CALLIANDRA															X	X
ALANG-ALANG			X				X	X	X						X	

Source : Economic plants of Indonesia, ORSTOM, 1991.